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**Productivity and Efficiency in the U.S. Food System, or,  
Might Cost Factors Support Increasing Mergers and Concentration?**

Catherine J. Morrison Paul

University of California, Davis

The author is a Professor in the Department of Agricultural Economics and member of the  
Giannini Foundation.

## Introduction

Productivity and efficiency are crucial aspects of production structure and economic performance in the food system, determining the welfare of not only producers and input suppliers, but also consumers. Characterizing this performance and its underlying determinants is fundamental to understanding market structure and for guiding policy implementation. Unfortunately, however, conceptualizing these notions, much less measuring them in some definitive way, is complex and problematic.

This was well documented at a conference in the mid-1980s (reported in the 1987 proceedings *Economic Efficiency in Agricultural and Food Marketing*), where a number of experts on production structure and performance aired their views about the potential for definitive productivity and efficiency measurement, and the use of such measures.

Armbruster summarized the proceedings with the somewhat euphemistic statement that efficiency is “not a homogeneous term.” Rausser, Perloff and Zusman were more dramatic in their statement that one encounters an “embarrassing richness of concepts, often poorly defined and unrelated” when looking for economic efficiency measures to analyze food marketing systems. Pope and Ladd threw in even more pessimistic notes when they said, respectively, that efficiency is “probably the most confusing word in economics,” and that efficiency measures are of “severely limited usefulness.” Not to be outdone in terms of gloom and doom, Just asserted that he saw a “a somewhat bleak picture of our abilities to generate accurate welfare measurements for the difficult issues of a complex, dynamic, uncertain, multimarket world.”

These statements suggest that we might as well put down our pencils (or computers) and go home, since, as French noted, these “pessimistic views might suggest possible

reduction in employment opportunities among agricultural economists.” But in the same volume, Milon commented that “efficiency analysis may be the premier growth industry among economists... (and that) in the past few years a “dizzying array” of new efficiency models/definitions have been brought in to analysis of ‘new territories’.” This seems to be telling us something – perhaps that the pessimism might be overstated, or at least that these issues are of significant interest and consequence.

A number of promising trends are apparent in the literature on the modeling and measurement of economic performance. Methodological developments with perhaps the most potential are those toward incorporating more structure on the underlying technological, behavioral and market relationships. This trend has, at least partly, been motivated by the proliferation of implementable duality and frontier models of production and efficiency in the theoretical literature. But it is also consistent with the empirical emphases of newly developing literatures, such as the “new endogenous growth” models (Romer and others), the “new empirical industrial organization” (Bresnahan and others), and the “new trade theory” (Krugman and others).

The literature also seems in a conceptual sense to be “going back to the basics” of costs and benefits. But researchers are now equipped with a far more sophisticated and powerful tool kit than in even the recent past, stemming from both recent refinements in theoretical and econometric models and techniques, and expanded data availability and potential for number-crunching from the explosion of information technology. These developments facilitate a more comprehensive and exhaustive characterization of supply and demand, or costs and benefits, than was previously feasible.

This conceptual base, which is consistent with my view of the most promising foundation from which to model and measure productivity and efficiency and to connect these aspects of the technological/cost structure with market structure, links back to a conference long preceding 1987. French referred to a 1955 conference where the focus of the efficiency discussion was simply the “ratio of ends to resources.” He stated that, in the 1950s, this was “viewed as a single concept, but with many applications,” rather than “the more global view of efficiency in this (conference) wherein the focus has been on aggregate social welfare,” (which) “adds greatly to the difficulty of making efficiency comparisons.”

The literature seems to be returning to such a foundation. More specifically, it is moving toward adding complexities to the basics, but reining in the expansion into the opaque and elusive realm of “social welfare.” This is consistent with my belief that “Everything We Really Need To Know, We Learned in Principles.” Most essential economic issues reduce to costs and benefits. But the recent literature also stresses both a careful and detailed representation of *true* costs and benefits and a conceptually appropriate measurement of *actual* economic values, thus broadening the welfare aspects.

This perspective is compatible with the statement by Rausser, Perloff and Zusman, that “a direct empirical analysis of economic efficiency of the food marketing system boils down essentially to a benefit-cost analysis.” And it is entirely in harmony with the focus of the 1955 conference as stated by French – “the ratio of ends to resources.” But this simplification part is guided by the kinds of questions raised in the 1987 volume about welfare, dynamics, externalities, and other concerns we need to address head on.

That is, it is crucial *which* costs and benefits are incorporated, and how they are measured. This again complicates matters, but from a somewhat different direction.

Improving economic performance fundamentally involves increasing the size of the overall “pie.” Even if we don’t rely on elusive notions like the compensation principle, obtaining the most benefits or output (broadly defined) from a given amount of resources or costs (also broadly defined), is the optimal outcome for all economic entities in the food system – suppliers, producers, and consumers. Such maximization of net benefits implies producing what people want in the best – most productive – way. And it embraces a wide variety of technological- or cost- and thus market-structure issues. But the primary building block is costs.

Giving short shrift to the cost representation seriously limits the construction of interpretable and usable indicators of economic performance. In particular, a detailed view of the technological characteristics and interactions embodied in the cost structure is an essential foundation for analysis of any notion that involves costs, including price-cost margins and market power as well as productivity and efficiency.

So I am back to the beginning – productivity, efficiency, and costs. In my exploration of questions involving the definition, measurement, and cost-, market structure-, and policy-linkages of productivity and efficiency, I will first summarize various conceptual issues underlying economic performance analysis. I will then overview studies that use differing methodologies to address issues of productivity and efficiency for the food system. And, finally, I’ll summarize what I see as their overall messages and implications, regarding both what has been learned about and how one might best approach such issues.

### **Motivation: the “new” cost economics (?)**

The first premise I will build on is that issues of productivity and efficiency fundamentally boil down to a comparison of costs and benefits. In the production context, this can be framed in terms of the resource or input costs of producing the benefits deriving from commodities or output. This basic notion is much more complex than it sounds, of course, when one realizes that production costs and benefits – or the prices and quantities of inputs and outputs – must be very carefully measured both to capture the actual economic values of marketed factors or commodities and to recognize non-marketed values. Effective implementation also requires characterizing various internal and external aspects of the production structure that affect the relationship of costs and outputs or benefits, such as production rigidities, cost economies (from, say, scale and scope), and spillovers.

In standard intermediate microeconomics terms, we need a full representation of the costs of production and its determinants, which we typically characterize by a cost function,  $TC(\mathbf{Y}, \bullet)$ , summarizing the minimum total costs (TC) of producing a given vector of outputs ( $\mathbf{Y}$ ), or aggregate  $Y$ . Efficiency involves getting the most output possible for a certain input level. That is, we want the cost-output or cost-benefit ratio  $TC/Y$  – or the cost curve in TC-Y space – to be as low as possible. Equivalently, we can express this optimization process as maximizing the  $Y/TC$  ratio.<sup>1</sup>

Most studies of productivity and efficiency focus on determining what the cost-benefit ratio  $TC/Y$  looks like, how its components might be measured, and how it is affected by exogenous or endogenous factors. The goal is, therefore, effectively or

appropriately to measure both the numerator and denominator of the TC/Y ratio. But this deceptively simple idea involves difficult questions about data and methodology, such as giving serious consideration to what the true costs and outputs (or benefits) are, how we might measure them, and how we can characterize their changes or determinants.

The most fundamental question involves data. What costs and benefits are important to include? Are marketed quantities and prices of inputs and outputs appropriate to use for such an exercise, or do we need to create or impute “effective” measures? Should quality characteristics of the inputs and outputs be taken into account? Are there non-marketed inputs or commodities (both good, such as food safety, and bad, such as environmental damage) that are important for more correctly approximating a welfare, rather than a purely market, measure? Is risk or uncertainty present that should be attributed a risk premium, or imply that information value should be incorporated? Do stock/flow problems require us to adjust observed prices to reflect their flow values? And, drawing on the market structure side of the problem, should we distinguish between marginal and average prices<sup>2</sup> if deviations stem from market structure characteristics?<sup>3</sup>

These questions not only need to be addressed, but also their implications for adaptation of measured cost and benefit levels established. For example, hedonic analysis might be used to accommodate changes in quality or characteristics. Or valuation of non-marketed inputs or outputs might be needed. Refinements of the

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<sup>1</sup> Of course, in terms of a cost-benefit valuation expressing  $Y$  in dollars may seem to be more useful. But this brings in output pricing issues that raise other aspects of market structure or profitability that are often useful to address separately.

<sup>2</sup> For example, compare prices or average revenue to marginal revenues (AR to MR) for outputs, or prices or average factor costs to marginal factor costs (AFC to MFC) for inputs.

<sup>3</sup> In this case we ultimately also need to determine whether this deviation between measured and actual economic determinants of behavior are a problem, or if they simply arise from, say, product differentiation that might have its own value.

observed data could be accomplished simply by constructing indexes, such as educational attainment for labor; or perhaps some form of parametric measurement might be used to identify shadow or virtual prices or quantities.

In turn, identifying the determinants of the TC/Y ratio becomes important for interpretation and use of productivity or efficiency measures. Characterizing the temporal, spatial, and technological nature of TC requires quantifying its dependence on the associated factors.

In particular, the technical change or productivity literature asks how this ratio changes over time, or with changes in R&D or other specific technological developments that are assumed to be exogenous. Including  $t$  (a time trend) or  $R$  (R&D) as an argument of the cost function implies that we wish to quantify and evaluate the proportional derivative  $\varepsilon_{TCt} = \partial \ln TC / \partial t$ , or  $\varepsilon_{TCR} = \partial \ln TC / \partial \ln R$ , that holds  $Y$  constant by definition, thereby reflecting a change in the TC/Y ratio.

Approximating such productivity changes in index number form involves taking the percentage change in TC, and subtracting the sum of the (share-weighted) percentage changes in  $Y$  and other arguments of the function (input prices), to see “what’s left” that is not captured in the recognized cost determinants.<sup>4</sup> This results in the Solow residual equation “measure of our ignorance,” that “sources” or identifies direct reasons for changes in the TC/Y ratio and attributes anything left over to some unidentified form of productivity growth – possibly attributable to, say,  $t$  or  $R$  changes.

Further analysis of productivity, however, requires decomposing this measure to identify its determinants by refining the input and output (cost and benefit) measures and



specifically characterizing other aspects of the underlying technological and behavioral structure. This is, explicitly or implicitly, the goal of much work in the productivity field.

For example, direct (parametric) estimation of the  $\epsilon_{TCt}$  or  $\epsilon_{TCR}$  measures can help us move in this direction by separating such impacts mathematically and statistically from the effects of other cost determinants or arguments. They act as shift factors for the cost-output relationship, or the cost curve. In a sense, such measures allow us to place weights on  $t$  or  $R$  changes in an expanded Solow residual computation.

We can similarly identify the contributions of technological characteristics such as scale economies to the cost-output relationship by computing the  $\epsilon_{TCY} = \partial \ln TC / \partial \ln Y$  elasticity – or marginal- to average-cost ratio – in a detailed fashion, rather than just assuming it is represented by a parameter (or equal to one). More generally, such a measure provides information on overall cost economies, since the cost-output relationship also embodies information on, say, scope economies.

This same idea also provides us a mechanism for valuing some kinds of production characteristics that are not represented directly in the data. For example, if short-run input rigidities exist, how might we distinguish the cost effect of these constraints from the potential long-run costs attainable when adjustment has taken place?

Accommodating this may in some cases be accomplished by adaptation of the data, such as multiplication of a capital stock variable by a utilization index. But estimation of shadow values or input-output interactions might also be necessary to characterize relationships not directly distinguishable from the data. Careful modeling of the

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<sup>4</sup> Alternatively, and more standard than the dual approach, such a residual may be computed by subtracting a share-weighted sum of percentage input changes from the percentage change in  $Y$ .

stochastic structure, such as allowing for errors in variables in the econometric analysis to reflect the deviation of market- from true- or effective-prices, could also prove fruitful.

More broadly, potential “fixes” to address – if in a partial and sometimes somewhat unsatisfactory manner – many of the problems involved in both measuring the numerator and denominator of the TC/Y ratio, and establishing its determinants, involve careful consideration of the true economic signals to which economic agents are responding. Representation of true, effective, shadow or virtual prices – and thus quantities – of inputs and outputs, in order to weight their contribution to the productive process, is often the crux of the problem.

Appropriate characterization of the cost-output or cost-benefit relationship and its determinants requires identifying and quantifying the causes of deviations between observed prices and their true values, such as dynamics, uncertainty, market failures, imperfect or missing markets, externalities, or quality variations. Such endeavors ultimately have promise for informing us about characteristics underlying technological and market structure, and resulting performance patterns in the industry.

### **Additional issues to keep in mind**

Some issues alluded to in this brief description of the cost structure and its productivity/efficiency implications deserve further emphasis and elaboration. First, most cost-based studies focus on multiple inputs (as few as just capital and labor, but ideally a broader spectrum of inputs to identify substitution patterns or interactions). In contrast, a single-output representation of production – even for an entire industry – is quite common. Still, output composition and quality seem just as important to characterize. The multiple-product and -market nature of the food system raises crucial

questions about output demand changes and product differentiation that can only be addressed in a framework that accommodates output composition patterns.

This leads to the related question of the *level* of analysis – are we evaluating a plant, a firm, an industry, the entire national food sector, or an even a more global entity? Differing questions (and answers) are relevant at each of these levels, as they are for the layers of the food chain – agriculture, processing, wholesaling and retailing. Widely varying characteristics and performance may be evident for these levels and layers of the system, and there may also be important spillover effects across them. This, in turn, raises aggregation issues, and debate about whether a top-down or bottom-up approach may be more fruitful for analysis of productivity, efficiency, and welfare in the sector.

Another issue is the role of various types of efficiency in the overall productivity or cost-output puzzle. Although there is a plethora of efficiency notions discussed in the literature, three standard distinctions stand out at the partial level of analysis I have carved out here – technical, allocative, and scale efficiency.

The question of technical efficiency is whether the technological potential typically represented by relationships such as a production function is attained, or whether individual decision-making-units (DMUs) – ideally firms or farms, but sometimes more aggregate divisions such as states – produce within a technological frontier or boundary. The issue of allocative efficiency in the context of the cost relationship is whether firms' input choices minimize costs (and thus the TC/Y ratio) at observed prices, or, alternatively, whether the production point is above or within the cost frontier.<sup>5</sup>

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<sup>5</sup> The term “allocative inefficiency” is also often used in the welfare literature to imply the existence of an output price-cost margin. This implies a deviation between the measured price and the marginal cost, using the underlying notion that efficient production implies a tangency of an output price ratio with a production possibility frontier. But this definition involves questions

A combination of technical and allocative inefficiency is the basis for “inefficiency” in the frontier literature. If a DMU is on the cost frontier as typically assumed in econometric analysis, both types of inefficiency are moot. But if either the technical or economic “optimization problem” has not been carried out effectively – so relationships like Shephard’s lemma are invalid – this should be taken into account.

It is particularly important, however, not only to identify the “inefficiency,” but also to explain where it derives from. That is, the inefficiency estimates in much of this literature seem another perspective on a “measure of our ignorance,” whereas the real point is to characterize the production technology and cost structure, so as to explain as completely as possible *why* firms/farms might lie within such a frontier.

In many cases, if measures of the prices and quantities of inputs and outputs are carefully constructed, and sufficient structure is put on these relationships to capture, for example, substitution patterns and the impacts of fixities, evidence of technical and allocative inefficiency disappears. So the standard assumptions in the literature on econometric estimation of cost and production functions are maintained,<sup>6</sup> although there are still reasons that an unidentified “inefficiency” could arise. For example, variation in management ability could generate differences among micro units. Recognizing such deviations could provide some insight about the cost-output relationship.

Scale efficiency is another factor often alluded to in productivity/efficiency studies. This efficiency notion essentially involves scale economies, or more broadly, cost

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of market structure that I would distinguish from the question of productive efficiency that is the focus here. Still, market structure is ultimately not only related to, but likely driven by, the cost structure and thus productive performance.

<sup>6</sup> That is, in my experience, once one characterizes as many production structure aspects as possible, unidentified “inefficiency” typically becomes minimal or disappears, at least when stochastic errors are appropriately represented, and true economic prices are measured.

economies (if, for example, multiple outputs and thus scope economies are a factor, or, perhaps, multiple plants and, thus, firm-level multi-plant economies). However, interpreting evidence of “scale inefficiency” is in many cases somewhat problematic.

The potential to take advantage of cost economies is a crucial aspect of productive efficiency and its link to market structure changes (such as increases in concentration, mergers and acquisitions, vertical and horizontal integration, or even more global trends toward foreign direct investment).<sup>7</sup> If cost economies are sufficient, it may be the case – given limited demand conditions and product differentiation – that production may optimally take place at a point where economies persist, such as in monopolistically competitive and contestable markets equilibria. Therefore, attributing “inefficiency” to scale factors must be undertaken with care; in particular, measuring and characterizing cost economies may be an essential part of the larger productivity picture.

Besides the impact on the TC/Y relationship of movements toward technological and cost frontiers (and thus greater technical and allocative efficiency), and toward the minimum point of an existing (multi-dimensional) cost curve, shifts in the curve are primary drivers of observed productivity patterns. Such shifts – like those from  $t$  and  $R$  changes – may derive from external factors (disembodied technical change, public R&D, education, infrastructure, regulation), or internal factors (induced innovation, private R&D, or technical change embodied in inputs). Shifts could also result from dynamic adjustment (movement between short-run curves rather than along a long-run curve). Distinguishing such determinants of the cost-output relationship is perhaps the most fundamental goal for evaluating productivity patterns.

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<sup>7</sup> Although such cost economies must be defined broadly, and interactions and linkages, such as those among outputs, plants, or even industry levels, need to be recognized.

This leaves us with a final issue – descriptive versus normative analysis. The cost-benefit or cost-output version of productivity or efficiency is more descriptive than normative as it says we simply want the largest “pie” possible – the most consumption from a given amount of resources. This outcome begs the question of what “should” be, especially in the sense of distribution. But distribution is, in my view, something we economists cannot deal with very well, unless values can be placed on its attributes.

Although I do not want to rely on the “compensation principle,” distribution issues can conceptually be addressed under the same umbrella as the cost-output ratio if they can be expressed as part of the true output (benefit) or cost measure. That is, if we can somehow place a value on, say, the maintenance of family farms, or determine the hardship costs of allowing the market to work. But, can non-market quality-of-life benefits of having family farms be built into a more appropriate measure of “social output”? Or can the costs of relaxing constraints such as education, liquidity, or other mobility factors be determined, to see if they can be mitigated (paid for, and thus become part of the cost base), yet still yield a lower TC/Y ratio while allowing larger-scale operations? Although the answers are not clear, these questions imply that adaptation of the TC/Y measure to reflect a more social-net-output concept has some potential, and that if compensation (say, providing education or funds to facilitate farmers’ mobility) seems justified, this should become part of the policy guidelines.

Other normative issues can somewhat more easily be embodied in the cost-benefit framework I am touting – although they again require valuing non-marketed inputs and outputs. For example, some studies have attempted to identify values for non-marketed “good outputs” such as food safety, and “bad outputs” like environmental damage from

pesticide use. Such adaptations in – or broadening the definitions of – costs and benefits move us away from descriptive market TC/Y computations, toward the realm of welfare.

Another distinction between the cost-output representation and traditional “welfare analysis,” with its normative ramifications, is that minimizing production costs for a given output level implies evaluating the cost-output ratio at one point. That is, both the level of and the impact of exogenous factors on TC/Y are evaluated at observed input and output levels. This is different from the approach of measuring “welfare triangles” from observed data points – it does not require imputing entire supply and demand schedules.

The more partial cost-based approach allows us to represent more details of each component of the analysis, rather than making simplistic assumptions. In particular, the total (or marginal) cost function is often summarized by one parameter in the welfare literature. However, a wide range of exogenous impacts, technological substitution possibilities, and price effects, need to be accommodated to effectively represent the cost structure and to use the resulting estimates to evaluate production and market structure.

Thus the cost-based representation is both simpler and deeper than traditional welfare analysis – simpler in terms of costs and benefits rather than a more elusive “welfare” concept, and deeper in terms of a detailed representation of inputs, outputs, and the cost structure. These attributes may be why we see an increasing number of studies in this genre. As alluded to above, this trend also coincides with the motivations of the “new” growth, IO, and trade literatures – all of which emphasize structural modeling, representation of interactions among economic agents or sectors, careful characterization of factors underlying supply and demand relationships, and consistency with theoretical optimization models.

## **The Literature: What has been done – and found?**

### **Traditional productivity measures: What do they tell us?**

Modeling productivity and efficiency within the cost-based or cost-benefit paradigm involves characterizing input costs (using measured prices and quantities of inputs) and usually one aggregate output, and comparing levels of and changes in these measures. Inputs may be limited to just labor and capital, but more often include, at least, energy, materials inputs, and land for agriculture. Output measures are typically based on production revenue data, deflated by a price index, usually defined by Divisia index number procedures.

The more detailed and precise (adjusted for quality or other measurable differences) the data are for the prices and quantities of the inputs and outputs, the more production cost declines (or output growth) can be decomposed into its various sources. And, if characterized explicitly in a production theoretic model, the more external and internal technological characteristics are represented – such as technical change (a time trend or, more explicitly, R&D or other knowledge factors), and cost economies – the more of the productivity residual “measure of our ignorance” may be explained.

Thus, such a framework has potential for establishing both levels and changes in productivity (the cost-output, input-output, or cost-benefit ratio), and identifying their determinants. And an understanding of such determinants suggests not only how greater efficiency/productivity might be stimulated – say, by regulation – but also how economic forces like cost economies might be driving observed market structure characteristics, such as concentration.



Standard productivity growth measurement is based on representing decreases in the TC/Y ratio (reductions in unit costs for a given output level) or increases in the Y/TC ratio (output expansion for a given input vector). Substitution is taken into account by constructing multi-factor measures that recognize changes in input use and composition, while other characteristics of the production structure, such as cost economies, are subsumed in the productivity residual “measure of our ignorance.”

A number of agricultural productivity studies of this genre appear in the literature. They typically find that productivity growth in U.S. agriculture is very strong – in fact, greater than in virtually any other sector over the past few decades. The estimates vary by study, depending on the underlying methodology and database, as well as the years represented. Trueblood and Ruttan (T&R), in fact, overview 14 different studies with productivity growth estimates ranging from 1.15 to 1.94 percent per year, with most of the studies reporting estimates about mid-range.<sup>8</sup>

T&R find that the differences in estimates are largely due to variations in the years covered rather than methodology used. And they emphasize that probably the most useful efforts to refine Solow residual-type estimates are those that more carefully address data issues, particularly for outputs and inputs likely to embody significant technical change such as capital and materials (seeds, pesticides).

Jorgenson and Stiroh (J&S) provide measures that are at the low end of the range identified by T&R – 1.17 percent per year from 1958-96. However, Jorgenson has suggested that these measures are likely biased downward from those based on data constructed at the USDA by Ball et al., and used for most existing studies. The J&S data

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<sup>8</sup> Although these differences may not seem that substantial, over time they could cause a significant variation in productivity levels.

may not sufficiently adapt for output quality, or capture the obsolescence of the capital stock embodied in the Ball data. Jorgenson and Stiroh also document that the agricultural sector is an important contributor to aggregate U.S. multi-factor productivity (MFP). In fact they place it third in the country<sup>9</sup> after Trade, and Electronic/Electric Equipment. And J&S provide an estimate of food processing sector productivity growth that is about half that of the agricultural sector, but still high compared to most U.S. industries – sixth after those named, plus Industrial Machinery/Equipment and Transport/Warehouse.

The J&S conclusions are consistent with other studies, such as Weston and Chiu, who focus on growth strategies and acquisitions in the food system, and find that “surviving food companies have demonstrated growth rates in revenues and returns to shareholders higher than the market as a whole.” And the J&S estimates contrast with the much higher productivity growth rates for agriculture and lower for food processing reported by Gopinath, Roe, and Shane, who, based on the Ball data for 1959-91, find a 2.31 percent MFP yearly growth rate for agriculture and a 0.41 percent growth rate for food processing

These strong growth patterns have been attributed to a number of factors, most notably R&D, even if the impact is not directly measured. For example, Jorgenson and Gollop assert that the high rate of measured technical change in agriculture is “consistent with” the story, dating back to early work by Griliches, of a significant R&D impact on U.S. agricultural productivity. Gopinath, Roe and Shane also rely on the importance of R&D when interpreting their results, suggesting that their findings should encourage policy measures supporting R&D, or other policies and regulations “affecting the

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<sup>9</sup> This is computed by multiplying the productivity growth rate by a Domar weight, which essentially reflects this sector’s share of GDP.

competitiveness of agriculture,” such as public infrastructure investment decisions. They also assert the existence and importance of spillover effects between food system layers that allow agricultural productivity growth to reduce processors’ costs, ultimately benefiting consumers.

In contrast to these supply determinants, Weston and Chiu, focusing on higher layers of the food chain, emphasize demand “drivers.” They indicate that food sector growth “has been achieved by a high rate of new product introductions, and promotion methods to develop ... international markets, and acquisitions and divestitures.”<sup>10</sup>

Heien instead ascribes trends and cycles in food sector productivity growth largely to adjustment costs – and the energy price changes that may have motivated capital adjustment in the 1950-77 period. He also notes the potential impact of environmental and safety regulation impacts on observed productivity growth patterns.

In addition to distinguishing among various layers of the food system, *industrial* disaggregation or decomposition helps to explain productivity patterns. This is consistent with Morrison, who finds quite different productivity patterns across the 3- and 4-digit SIC divisions within the 2-digit SIC food processing sector, that are veiled in more aggregate measures. A spatial rather than industrial division also reaps benefits in terms of interpretation; Ball et al. estimate productivity growth by state and find significant variation across states and regions. They determine, however, that “interstate shifts in production activity and resource reallocations have had little impact.”

It is sometimes useful to separately identify differing types of input productivity. For example, Adelaja considers changes in materials (M) productivity resulting from

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<sup>10</sup> They also emphasize that the most productive acquisitions seem to have been primarily “close to (company’s) core food activities.”

changing economic conditions in food processing industries, and finds that rising material prices, wage rates, and regulation, and declining food prices, have stimulated greater materials productivity. In the short run, he attributes these impacts to substitution, and in the long run to material-saving (induced) technical change. Similarly, Paul and MacDonald look at primary *agricultural* materials use in food processing, and find that M-productivity has been enhanced, as demand has tempered, due to technological and consumer demand pattern changes in the food processing industries.

### **Extensions to the traditional analysis: What do they add?**

A number of complications or refinements may be incorporated more directly into the basic model underlying standard productivity analysis to provide additional insights about productivity and efficiency patterns in the food system. This subsection overviews such complicating factors as structural change, dynamics, multiple markets, and externalities, which are targeted in the literature as possible reasons for the “bleak prognosis” of welfare analysis, or as unidentified determinants of the Solow residual.

Studies that incorporate such refinements span the several layers of the food system – from primary agriculture to retail. Although they focus primarily on the agricultural and processing sectors, important issues emerge about productivity and efficiency spillovers across layers, and how spillovers may stimulate integration that facilitates efficiency through scale and scope economies, maintenance of capacity utilization levels, internalization of externalities, and attenuation of risk.

### *Technical and Structural Change*

The most fundamental – but also perhaps the most difficult – issue that arises in this literature is how to more explicitly characterize structural and technical change than is

possible using a residual method. Standard analyses of productivity growth, at least indirectly, imply that technical change can be represented by a time trend. Similarly, structural change might be represented by a discrete shift in technology, perhaps through a distinction between patterns across time periods (or countries or regions) in a nonparametric framework, or a dummy variable fixed effect or shift term in a parametric treatment. The role of more specific technological determinants, such as R&D, is sometimes simply asserted, or may be incorporated as an argument of the production or cost structure (with some type of lag structure appended).

However, the recent literature includes a number of studies that more directly characterize technical or structural change within a production theory model of input demand (and thus cost) behavior. For example, Celikkol and Stefanou recognize endogenous technical change from price-induced innovation, in addition to the standard exogenous technical change time trend, in a profit maximization model of the U.S. food processing and distribution sector. Their approach incorporates long-run prices as a factor stimulating firms to seek innovations. They find that this form of technical progress “has a dominant contribution on input decisions compared with exogenous technical change,” and provide evidence that expectations are important to model for appropriate representation of production processes and productivity. Their results also suggest “wide changes in aggregate technical change patterns” and biases (farm-input-saving and non-farm and capital-input-using), and little substitution between farm and non-farm inputs, but increasing substitution (flexibility) over time.

Goodwin and Brester model structural change in the food processing industry by appending multivariate gradual switching regression techniques and Bayesian inferential

procedures to a cost-based translog model of factor demand. They also find that production processes have become more flexible (greater substitution possibilities, except possibly for labor), allowing the system to more closely approximate a productive optimum, but that such changes stem from capital-using and labor-saving biases.

Structural change is modeled in Evenson and Huffman for U.S. agriculture in terms of changes in farm size, specialization, and part-time farming. Their results suggest that R&D, extension, and government commodity programs have had impacts on both farm structure and MFP, although input price changes, rather than technology or regulation, seem to have had the greatest impact on farm size. This finding links structural change to the potential for scale, size, and scope economies.

Morrison allows for capital-embodied technical change by incorporating dynamic capital adjustment processes for three separate capital inputs, including high-tech capital, for the U.S. food processing industry. She finds that cost-savings derived from investment in high-tech inputs are augmented by long-term increases in capital intensity and by the exacerbating effect of high-tech investment on disembodied technical change.

Technical change has often been characterized by expressing R&D as a direct determinant of the cost-output relationship. For example, Morrison and Siegel focus on external R&D impacts in food processing – or spillovers within the sector – by incorporating a “knowledge capital” vector comprised of high-tech, human, and research (R&D) capital into a cost-function-based model.

Chavas Aliber and Cox and Chavas and Cox focus on the distinction between private and public R&D in agriculture.<sup>11</sup> Their nonparametric treatment is based on the weak

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<sup>11</sup> This is just one example in the wide ranging, but not yet definitive, literature on R&D impacts in the agricultural sector that is comprehensively overviewed by Alston et al.

axiom of profit maximization (rather than a functional representation of technology and behavior) and the specification of “netput” augmentation (that transforms actual into effective netputs). They find large rates of return to R&D that are higher for private research in the short and public research in the longer term. They also obtain support for induced innovation in “actively traded” inputs, but less so for land and labor inputs.

Measured rates of return to R&D vary dramatically across studies, largely attributable to the difficulty of establishing the lags or dynamic pattern for internal R&D investment and the spillover impacts of external R&D. But most studies find a significant contribution of R&D to the food system – and especially agriculture. Makki, Tweeten and Thraen, for example, who estimate relatively low rates of return, still find that they are “high enough to justify continued public investments to raise productivity,” and suggest that “shifting public funds from commodity programs to education and research would raise U.S. agricultural productivity.”

### *Rigidities and Dynamics*

The effects of rigidities (or lack of flexibility/mobility) have often been highlighted in the literature on technical and structural change. Many studies in the past couple of decades have directly addressed this issue, along with the resulting importance of utilization changes, sunk costs, dynamics, and expectations. Constraints on rapid adjustment to economic conditions may affect not only capital, but also labor and land. In fact, many researchers believe the rigidities associated with labor may be the most significant factor inhibiting adjustment processes in agriculture.

For example, Arnade and Gopinath use output supply and capital investment functions to model capital adjustment in the U.S. agricultural and food processing

sectors. They find that agricultural capital adjusts very slowly (it is “almost fixed” at 2 percent adjustment per year), but that food processing is more flexible (full adjustment takes less than five years). If these estimates are representative, lack of flexibility imposes serious limitations on productivity growth, implying that investment incentives to mitigate the effects of rigidities should be a primary goal of policy measures to enhance performance.

Morrison focuses on capital investment in the food processing sector, using a cost-based model allowing for short-term constraints on capital stock adjustment. The costs of the rigidities are represented by deviations of shadow values for the capital flow (or utilized capital) from market investment prices for the capital stock. The resulting measures support the notion that capital adjusts somewhat slowly in the processing industries, so full equilibrium is not attained within a year, but suggest that newer high-tech equipment exhibits lower adjustment costs and greater flexibility.

Stefanou recognizes both adjustment costs and uncertainty in a more complex dynamic dual (value function-based) model for U.S. agriculture. Luh and Stefanou [1991] expand on this treatment, and determine that both capital and labor “adjust sluggishly to their long-run equilibrium levels.” This finding suggests that “asset fixity is important in U.S. agricultural production,” although they do not find the extreme inflexibility suggested by Arnade and Gopinath. They emphasize that if such rigidities are not recognized in studies linking MFP to R&D or other technological determinants the contribution of these determinants is “misrepresented,” for some inputs are not at their long-run equilibrium levels.<sup>12</sup>

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<sup>12</sup> They also find that technical change dominates the growth of total factor productivity, with scale, quality, and disequilibrium factors explaining only 3.44 percent of the growth.



Luh and Stefanou [1993] pursue this further to bring learning into the picture as a (internal) knowledge factor, and find that this reduces the “role for technical change and assigns a substantial role to the ... contribution of learning-by-doing to the growth of the aggregate agriculture industry.” They find that evidence of slow capital adjustment seems mitigated when learning and its dynamic aspects are recognized, with knowledge facilitating the adaptation process, although slow adjustment of labor is still an important constraint on productivity.

### *Regulation*

Another likely determinant of – or constraint on – productivity and efficiency is regulation. If regulatory factors are fixed, they may be considered part of the operating environment, but in many cases it is regulatory *changes* that are important to investigate. The treatment of the regulatory constraint involves determining the (shadow) costs of the restriction, as is often done for input fixities.

A particular focus in the literature addressing the effect of regulation has been on the efficiency effects of reducing regulatory distortions by major reforms. In a series of related papers, for example, Kalaitzandonakes and Bredahl, Kalaitzandonakes, Gehrke and Bredahl, and Kalaitzandonakes show the enhancement in technical efficiency from increased liberalization, greater competitiveness, or reduced protectionism in agriculture for various countries. Lachal also finds evidence that regulatory reform is positively associated with technical efficiency.

Paul et al., however, using a model that allows for less restricted input and output substitutability, determine that impacts from regulation reforms involve changes in input and especially output composition in response to changing economic (price)

inducements. This finding suggests both that the response to reform should be characterized in terms of allocative, rather than technical, efficiency, due to adjustment lags that slow the transition, and that explicit recognition of substitution and composition adaptations for inputs *and* outputs is needed to understand efficiency patterns.

Hu and Antle also explore agricultural policy effects on productivity across countries, and find a significant impact that is “large and statistically significant only for those countries that tax or subsidize agriculture moderately.” They interpret this as evidence that farmer incentives in other countries are “distorted” to such a degree that marginal changes in policy do not measurably affect their behavior.” Their results also suggest that decreased protection is consistent with higher (lower) productivity when agriculture is taxed (subsidized).

Lopez and Pagoulatos take a different perspective on regulatory impacts and their political linkages in U.S. food processing. They find that “trade protection tends to be lower in higher concentrated industries,” but “as the number of firms increases, there is a downward pressure on trade protection, possibly as a result of increased organizational cost for lobbying.” Both Hu and Antle and Lopez and Pagoulatos stress the costs associated with high levels of and distortions associated with regulation.

#### *Cost Economies – Internal and External*

In addition to the effects of input or regulatory rigidities on farm/firm responsiveness and economic performance, production characteristics imbedded in the technology may have important roles in determining efficiency and productivity patterns. The most common factor under this heading is scale economies, reflected in the slope of the average *long-run* cost curve or a difference between *long-run* marginal and average costs,

because in the short run such characteristics are likely due to input fixities. Of course, if scale economies prevail within the plant or firm size range in an industry, larger-scale operations will be more efficient in terms of unit costs of production.

Various other types of cost economies might also exist, such as scope economies (complementarities between outputs such that increasing  $Y_1$  causes the  $Y_2$  cost curve to drop). Economies may arise from linkages that cause lower production costs for multi-plant firms; examples include spreading across plants of managerial skill, hiring, or information (advertising and connections with suppliers). Other types of linkages, spillovers, or agglomeration (thick market) effects could also augment the efficiency of larger or more diversified operations. The existence of such economies, and their proliferation in our age of extensive technological innovation and information, may well be an important driving force for productivity, efficiency, and resulting concentration.

A number of studies suggest the importance of cost characteristics in determining plant, firm, or industry productivity. Kerkvliet et al., for example, allowing for changes in both technical change and efficiency, suggest that concentration increases in the brewing industry were due to escalation in advertising expenditures and greater scale economies (which may be connected, and also are likely to increase sunk costs).

Stefanou and Madden focus on size economies in a methodological study that emphasizes the importance of differential scale effects across inputs, or scale biases, and of distinguishing short- from long-run scale economies. They also link uncertainty with cost economies, particularly scope or “multi-product enterprises” and fixities.

MacDonald discusses the importance of scope economies, defined as complementarities across outputs implying that product diversity is cost-saving and, thus,

productivity enhancing.<sup>13</sup> MacDonald links these complementarities to firm expansion and concentration. He indicates that the presence of scope economies can “help us understand why integrated, diversified corporate structures have developed,” and “in ascertaining the costs and benefits, both private and public, of corporate mergers, vertical integration, diversification, and foreign investment.” However, this conceptual study does not provide estimates of scope economy impacts, whereas Paul finds evidence that scope economies explain nearly one-third of measured cost economies in beef packing.

The importance of these and other cost structure characteristics for understanding productivity patterns is sometimes given lip service in empirical work, such as in Bhyuan and Lopez [1995, 1998b] who “underscore the importance of cost structure assumptions” for evaluation of welfare. But – as in most of in the “welfare” literature – these studies make simple one-parameter assumptions about the cost-output relationship, precluding consideration of cost economy components.<sup>14</sup>

Although economies of scale, size, and scope are based on the shapes of cost functions, or shifts due to (internal) firm decisions, such as output supply and plant numbers/sizes, external cost factors are also important to recognize. Some of these – in particular, exogenous technical change and public R&D investment – have already been mentioned and are often recognized in productivity studies. However, “scale economies” from other external factors, possibly resulting from spillovers or externalities due to the public good nature of some types of investment, might also be characterized.

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<sup>13</sup> Value associated with product diversity or differentiation might also derive from spreading risk due to uncertain consumer choices, or, simply, from consumers’ desires and, thus, demand for a broad choice of commodities.

<sup>14</sup> Or, in many cases, the even stricter assumption of constant returns to scale is imposed.

For example, public investment in infrastructure, education, or extension could have vital impacts that should be recognized for a full representation of productivity and its determinants and for policy guidance. Also playing possible key roles as productivity “drivers” are agglomeration effects or (horizontal or vertical) spillovers across firms due to thick markets, high-tech capital proliferation (and enhanced information and communication), and private R&D investment that generates externalities.

Morrison and Siegel explore shift impacts on the TC/Y ratio from external or industry-wide R&D, high-tech, and human capital. They determine that significant scale economies in food processing can be partially attributed to these knowledge factors and their substitutability with private capital. The cost-saving value seems greatest for R&D in proportional terms, although the dramatic observed expansion of high-tech capital causes its total impact to be larger, and is smaller but still significant (statistically and in magnitude) for human capital.

#### *Non- or Imperfectly-Marketed Costs and Benefits*

Other non-marketed “goods” and “bads” may also be important to incorporate for appropriate measurement and interpretation of cost-benefit ratios. For example, quality-of-life factors such as food safety and environmental protection have a value, but also impose costs (with no compensatory benefit as non-marketed goods) on firms. Some work on establishing the values and costs of such factors, and, thus, their role in cost-benefit computations, has been undertaken. However, missing markets are hard to address in productivity analysis, due to the wide range of potential “environmental” commodities that might be considered, and the difficulties of valuing them.<sup>15</sup>

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<sup>15</sup> This is consistent with the emphasis by Ladd on quality-of-life determinants, and Milon in the broader context of “social philosophy” performance objectives or goals. Pope also refers to

Efforts toward quantifying the benefits and costs of food safety are summarized and discussed by Antle [1995, 1996] and Caswell [1998], who indicate that a fair amount of work has been done on valuing food safety benefits, but not much has been done to incorporate this in productivity analyses. Further, even less attention has been paid to the cost side of the food safety problem that could potentially be addressed by incorporating a measure of compliance costs into a cost structure framework.

Studies have also begun incorporating environmental damage from agricultural processes into the representation and measurement of agricultural production processes and productivity.<sup>16</sup> These studies, including Ball, Färe, Grosskopf, Hernandez-Sancho and Nehring; and Ball, Felthoven, Nehring and Paul, find statistically significant – but not large in magnitude – costs of reducing risk from leaching and runoff. It also seems that the costs of restricting risk largely stem from technological change embodied in pesticide inputs, implying that induced technical change is a central part of the puzzle. This work does not address the corresponding value of leaching and runoff risk reduction, but provides a base from which to compare its costs and benefits.

The impacts of uncertainty, risk, and information have also been recognized in the literature on productivity and efficiency, although few direct insights about their contribution or measurement seem established. In fact, Pope, who has done important work on uncertainty and risk, indicates that characterizing uncertainty and risk may not be particularly important for welfare and productivity representation.

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externalities that cause markets to fail, that might involve “public goods, adverse selection, moral hazard, or other phenomena where markets cannot exhaust the gains,” so “one must rely on other than solely market means to obtain welfare measures.”

<sup>16</sup> This work has been carried out using data on “bad output” risk due to leaching and runoff from agricultural chemicals use developed by Ball, Nehring, Kellogg and others at the USDA/ERS.

Studies addressing uncertainty issues suggest that risk premia might be used to reflect the effective prices farmers/firms respond to. Doing so would also imply that a value should be placed on information; this might, to some extent, be addressed by recognizing advertising expenditures and resulting demand changes. In addition, risk, information, and advertising may be linked to perceived cost economies. That is, risk may be spread at larger scales of production, and advertising and information may have scale effects.

For example, Kerkvliet et al. emphasize that concentration may be due to escalation in advertising expenditures, as well as scale economies. Antonovitz and Roe determine that information values increase with the amount of risk. Farrell and Tozer consider the value of labeling and grading, which is “designed to improve price signals;” this is similar to Caswell’s emphasis on the value of labeling to food safety and nutrition. Reed and Clark establish the unpredictable nature of structural change and consumer behavior, and report that this “poses considerable risk to food producers and can induce industrial reorganizations that spread this risk across stages of food production.”

### *The Demand Side*

Most of the issues and associated studies reviewed so far for productivity modeling and measurement focus on the cost side. While the cost side is central and an often neglected piece of the puzzle in welfare and market structure evaluation, key cost- and benefit-drivers, of course, also stem from the demand side.

One important point is the value of product differentiation. Issues regarding multiple products and thus output composition changes have not often been targeted in productivity studies but may provide crucial clues about productivity and efficiency.

Bringing this explicitly into the analysis involves recognizing new products and characteristics of existing products, as well as distinguishing among types of outputs.

This refinement of the cost-output framework is particularly important as the food system has been characterized for at least the last couple of decades by dramatic changes in consumer demand toward convenience foods and diversity in quality and types of food products. These demand-driven output composition changes, as recognized by Goodwin and Brester, and Reed and Clark, are factors underlying (induced) structural change in the food processing industries that may be as important as technological change in determining the true cost benefit ratio for food products. Wills and Mueller, in fact, assert that product differentiation (and its link to advertising) provides an “alternative explanation” to collusion or efficiency (cost economies) for price-cost margins.

Note that demand adaptations may also stem from changes in markets served – such as movements into export markets. Lee and Schluter, for example, assess “sources” of output changes in the food system in terms of domestic final demand, export demand, and inter-industry demand, in a descriptive analysis of demand “drivers.” They find that between 1972 and 1982 “export expansion influenced farm output slightly more than domestic demand did, while domestic demands influenced processed food output more than export demand did.” Thus, policies affecting export competitiveness seem more likely to enhance agricultural productivity, while those targeting the health and spending power of domestic consumers have more effect on performance in the processing sector.

Finally, because quality changes and new products are not readily measurable, changes in the composition or characteristics of output may simply cause mis-



measurement of output quantities, biasing the cost-output ratios, Thus, to avoid bias, appropriate measures of “effective” output must be fashioned to reflect quality changes.

### **So what messages do we get from this literature?**

An important message from the literature is that a detailed cost structure representation is an essential foundation of production and market structure analyses, and that such a structure fundamentally involves the appropriate measurement of “effective” input and output prices and quantities. And any lack of perfectly competitive markets (where market values fail to capture the relevant aspects of commodities) must be taken into account. Adaptations must also be made whenever measured values do not reflect the true economic concepts we wish to represent.

The representation of virtual, shadow, or “effective” prices and quantities may be pursued through careful measurement techniques.<sup>17</sup> The appropriate methods for data adaptation depend on the question being addressed and the reasons for the deviations of (average) market and true economic values (or levels) of the productive factors and commodities under consideration. One approach is simply to recognize changes in output or input composition through disaggregation. Variations in characteristics or quality may alternatively be accounted for by creating quality indexes (such as for educational attainment), or using hedonic techniques. Or parametric estimation of shadow values might be carried out, for example, to accommodate rigidities from input fixities or regulation, to incorporate knowledge factors like learning, or to establish values for non-marketed goods (or bads).

Deviations of measured prices from their true economic benefits or costs have, in various contexts, been recognized as key factors in the measurement and interpretation of

performance indicators. For example, Celikkol and Stefanou emphasize that price measures should reflect long-run expectations and that the role of these prices in inducing technical change should be incorporated. A primary concern of Chavas and Cox is the transformation of actual into effective netput quantities, with an induced innovation motivation. The measurement of shadow values to represent the true flow values of quasi-fixed inputs is (explicitly or implicitly) the purpose of the treatments of capital by Morrison, and of capital and labor by Luh and Stefanou [1991]. In Luh and Stefanou [1993], learning is recognized to be a stock resource associated with the quality of labor that should be taken into account for appropriate valuation of labor. Ball, Felthoven, Nehring, and Paul stress the importance of computing shadow values for non-marketed “bad” outputs, i.e., risk from leaching and runoff, and constructing hedonic measures for *effective* pesticide prices and quantities. And Morrison and Siegel emphasize the characterization of true marginal, as distinguished from average, costs as the point of cost economy (such as scale and scope) measurement and analysis.

In fact many – if not most – of the issues raised in previous sections and in the literature can be embraced within this conceptual framework. Adaptation for deviations of market and effective values of factors and commodities, and establishing their determinants, may involve characterizing a broad range of shadow values or virtual prices for mis-measured, public-good, or otherwise imperfectly-marketed inputs and outputs, as well as accommodating changes in input and output composition or differentiation. Such mechanisms also have potential for bringing “quality of life” factors into the picture. And they may provide vehicles for valuing information (perhaps

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<sup>17</sup> In the virtual price framework this concept is often attributed to Fulginiti and Perrin.

by recognizing advertising costs and demand impacts), or uncertainty and risk (for example, by adapting prices for expectations or by a risk premium).

Another central issue for food sector productivity analysis is distinguishing among layers and levels of the system, and their individual and linked roles in overall performance. In particular, although the layers of the food sector are useful to evaluate individually, identifying spillovers across them is essential for appraising overall sectoral performance and understanding driving forces toward integration, as emphasized by Gopinath, Roe and Shane for the United States, and MacDonald, Rayner and Bates for the United Kingdom.<sup>18</sup>

Similarly, both diversity and linkages across products and plants/firms/industries are key factors underlying observed economic performance and its role in stimulating mergers and acquisitions. Especially crucial for understanding trends in the food sector is the exploration of technological and demand forces motivating increased product differentiation, complementarities among products, new product development, and expanding demand for a diverse range of food items.

Analysis at various levels of industry aggregation may also illuminate aspects of production structure and productivity. And, as highlighted by Traill and increasingly emphasized in the literature on trade and competitiveness, even broader globalization issues have “important implications for productivity and growth, and market integration,” at least partly due to convergence in consumer demand, and to the “exploitation of economies of scale in finely differentiated markets.”

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<sup>18</sup> This is particularly crucial since, as French notes, the “food system beyond the farm gate” is growing, but productivity growth at higher levels of the chain is less than at primary levels.

Another point is that knowledge not only of cost-benefit or productivity *levels* but also of their *determinants* is important to understand food system performance. Because of fundamental links between productivity and efficiency, and between cost and market structure, cost-based or cost-structure measures can provide essential insights about the driving forces of market structure patterns such as mergers and concentration.

A major focus of efficiency measurement in agricultural economics has been on establishing the extent of “welfare losses” from market power, based on deviations between measured output prices and marginal costs. The issues raised here about the cost side of this problem, however, suggest that various production characteristics could underlie such deviations. So attributing “welfare loss” to price-cost margins raises the question: Is this deviation truly an indication of inefficiency, or is it something else?

The first potential offsetting factor or driver from the cost side, which has been batted around at least since the early 1970s due to Demsetz and others, is scale-, or more generally cost-economies. For example, Kerkvliet et al. find that scale “inefficiencies” in the brewing industry imply a deviation between price and marginal cost, but that lack of excessive profitability suggests “market power exercised is very small.” Azzam and Schroeter establish that “the estimated cost savings necessary to neutralize the anticompetitive effects of consolidation in beef packing are about half the actual cost savings from scale economies.” And Paul determines for the beef packing industry that short- (utilization) and long-run cost economies underlie the price-cost margin, while low profitability is maintained by effective competition.<sup>19</sup> Such indicators of efficiency

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<sup>19</sup> Park and Weliwita also find that mergers and acquisitions helped regain some profitability for food retail enterprises in the 1990s, compared to the “steep declines” of the late 1980s. But they indicate that this recovery does not seem consistent with markup behavior, implying instead that this movement is based on costs and on product demand/differentiation.

motivators for measured “market power” are also consistent with studies that reveal a positive relationship of mergers and acquisitions to productivity and wage growth, employment, and survival, as in McGuckin, Nguyen and Reznick.

Other drivers for an observed price-marginal cost wedge that do not necessarily imply inefficiency – or that  $TC/Y$  is higher than necessary given technological and demand conditions – have also been explored. For example, Reed et al. note that “failure to account for product diversity and uncertainty has been shown to seriously affect tests of market power,” and suggest that concentration may stem from the “unpredictable nature of trends in consumer demand, and not imperfect competition.” Along the same lines, Gopinath and Vasavada state that “deadweight losses from imperfect competition may be offset by greater product variety and quality of food products for consumers,” and determine that R&D is more prevalent in firms exhibiting noncompetitive behavior, providing support for Demsetz-like efficiency/innovation arguments. Gopinath, Pick and Worth find offsets from “dynamic welfare gains such as reduced price variability.”<sup>20</sup>

Studies that relate “welfare losses” to their determinants, such as Bhyuan and Lopez [1998a], find that more extensive “market power is found in markets with greater exports, advertising, economies of scale, mergers and acquisitions and concentration.” But alternatively, price/cost margins may be misleading indicators of market power for firms with high advertising expenses and scale economies. Rather, these characteristics of production are driving factors for exports, concentration, and mergers and acquisitions.

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<sup>20</sup> This conclusion stems from their finding that “the rate of inflation and product heterogeneity increase intra-industry price variability in food industries, but industrial concentration lowers the sensitivity of relative prices to changes in the rate of inflation.”

Similarly, Lopez and Bhuyan state that “losses” are “likely to be higher in markets characterized by high R&D and advertising intensities, with highly concentrated sellers of consumer products facing lower import competition.” On the other hand, R&D and advertising are activities designed to differentiate a product, and have both a cost and a value crucial for interpretation of true costs and benefits of production yet too often ignored in welfare loss studies. They also determine that import competition is likely to be lower in industries that are innovative and efficient, but this alternatively implies a crucial role for cost economies.

In sum, various aspects of the production or cost and demand structure of firms in the food system are indicators of both stimuli for concentration *and* enhanced efficiency. Cost economies (that imply both lower costs and a greater proportion of sunk costs at higher or more diversified scales of operation), short-run rigidities (that affect flexibility and the importance of maintaining utilization levels), innovation, product/firm differentiation, and advertising, all may be more fundamental determinants of mergers and concentration than is a desire to “exploit” or “exercise” market power. Thus, mergers and acquisitions may be an efficient result, rather than a determinant of structure.

The dependence of market structure on the underlying cost structure also flows over into the global spectrum. Field and Pagoulatos find that a “positive relationship between import share and margins and the negative effect of exports suggest that it is expanding exports rather than increasing import penetration that results in competitive pressure from abroad.” Reed says that foreign direct investment (FDI) imparts “three advantages to firms”; they may, in the foreign market, “exploit a comparative advantage in management skill, realize economies of scale or size, and acquire more precise information on

consumer behavior.” And Solana-Rosilla and Abbott assert that “firm competitiveness in international trade and in the use of FDI to go abroad is ... related to the phenomena that gave rise to the new trade theory – imperfect competition, product differentiation, and economies of scale.”

Thus, to address market structure issues, we clearly need a rich representation of cost, as well as demand, relationships underlying observed costs and benefits and productivity/efficiency. Characterizing the cost structure effectively seems the most neglected piece of the puzzle in market structure analysis, although it has increasingly become the focus of the productivity literature. Without this base, measures of production or market structure are limited in their interpretability and usefulness.

#### **Concluding Remarks: What do we know and where do we go from here?**

This paper overviews the conceptual, methodological, and empirical issues and findings that I believe crucial for considering “what we know” about food system productivity and efficiency, and where it might be “productive” to move from here.

The empirical literature shows that the U.S. food sector has exhibited stronger productivity growth than most sectors of the economy, with productivity gains especially marked for agriculture, but slower growth rates as we move “up the food chain.” The importance of spillovers across layers of the system, the diversity of industry sectors, regions, and plants/firms, and changes in the composition and quality of both inputs and outputs was emphasized. And numerous determinants of observed productivity gains were highlighted, including R&D, flexibility and dynamics, and various induced, internal, and external knowledge-based factors underlying cost economies and shifts.

In particular, the importance of production flexibility, both to reach optimal cost-output levels rapidly in response to changes in the economic and technological climate, and to adapt to diverse and changing product demands, has been established. The role of technology embodied in new capital investment, and the knowledge or education of laborers, in motivating flexibility and mobility has been documented. Innovation stemming from R&D that may be induced by observed input prices has been identified as more important than general technical change trends, although the returns to both public and private R&D still defy clear quantification. The limiting effects of rigidities from excessive regulation have been recognized. Crucial cost structure aspects that affect (internal and external) cost economies and thus productivity, such as utilization changes, scale and size effects, and scope economies, have been emphasized. And the role of input – and potentially output – biases from all of these impacts (and from adaptations in consumer demand patterns), in the context of compositional changes, has been stressed.

Thus it seems clear that policy to facilitate flexibility – by increasing knowledge as well as encouraging innovation and investment – will reap gains by enhancing adjustment and spillovers. Stimulating technical change is also important, although which are the most important technical change “drivers” is not yet well understood. And the role of various types of cost economies should be recognized, so that regulations are not imposed that limit their potential cost-saving impacts.

Although it is difficult to construct a single, sufficiently broad model to embrace all of these productivity determinants in a consistent and implementable fashion, inroads have been made toward measuring many of them individually, and sometimes enough characteristics have been imbedded in models to also determine their relative impacts.



More information quantifying the absolute and relative contributions of these and other types of productivity factors will be important in guiding policy development.

In terms of methodology, increasing attention on the appropriate measurement of inputs and outputs embodied in the cost-output ratio underlying productivity/efficiency – which can be pursued through careful data construction, disaggregation, hedonic analysis, or parametric estimation of virtual or shadow prices – has been emphasized. The fundamental role of a full consistent representation of the cost structure and its characteristics as a basis for evaluation of performance in the food system has been underscored. These pieces of the puzzle, although essential for justifiable representation of economic performance, and the use of resulting measures for policy guidance, imply that a somewhat different perspective may be more fruitful than the traditional welfare analysis approach.

Some of these points are consistent with those emphasized in recent literatures. The “new industrial organization” literature (NEIO) stresses structural modeling and theoretical underpinnings, although the cost representation is often neglected given the primary IO attention on the demand side. The “new trade theory” recognizes the importance of imperfect competition, which is not necessarily characterized as “bad,” but as supported by product differentiation and scale economies. And the “new growth theory” highlights the key role of knowledge factors through their impact on “scale” economies and spillovers.

Conceptually, I have stressed the fundamental notion of getting the net-benefit “pie” as large as possible – or the greatest benefits from existing resources – as the basis for productivity/efficiency. But the need for careful definition of both the cost and

benefit/output components has also been underscored. Such a focus is less complicated than a full “welfare” treatment, as it supports more partial analyses and glosses over distributional issues. But the approach involves increasing complexity in other directions – careful representation of true or effective as contrasted with market economic benefits and costs, and a full structural model of both costs and benefits.

Although this complex modeling is not straightforward to pursue, much of the recent literature is consistent with its goals. It focuses on identifying and quantifying rigidities that limit, or knowledge factors that enhance, flexibility and technology, and netput characteristics that affect input and output measurement. Such developments provide an important thrust in the right direction, but much more must be accomplished.

So we end up at quite a different place than was suggested by Just’s lament that the future is “bleak” for welfare analysis, and that we are “doomed to continue to view economic phenomena from various economic perspectives...that generate different levels of clarity versus conflict in each new problem.” My overview does suggest that there is such a wide range of issues surrounding the appropriate measurement of both “blades of the scissors” – costs and benefits – underlying productivity and efficiency that no one study or even paradigm will give us all the answers. We do, however, seem to be moving in a promising direction. And as work proceeds along these lines we can hope to gain some consensus about the key factors underlying productivity patterns.

This leaves open Shaffer’s question of policy relevance: Since the term efficiency “ranges in meaning from the seemingly simple notion of the ratio of output to input to the complex and esoteric notion of the maximization of total welfare,”...what can economists “legitimately say in informing policy based upon the economic concepts of efficiency”?

The essential issue is measuring the level and changes in effective net output from the food system and its determinants. By refining input and output measures, recognizing joint- and imperfectly-marketed factors and commodities, and focusing on structural representation of costs and benefits, we will be developing a richer basis for identifying performance linkages that, in turn, serve to guide policy decisions.

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